ATTACHMENT 3-9
DTTF ENVIRONMENTAL PERFORMANCE STANDARDS

1.0 INTRODUCTION

This attachment presents environmental performance standards for the Dugway Thermal Treatment Facility (DTTF) required by R315-3-2.14 and R315-8-16 and is organized in the following sections:

- Prevention of any releases that may have adverse effects on human health or the environment due to migration of waste constituents in the ground water or subsurface environment;
- Prevention of any releases that may have adverse effects on human health or the environment due to migration of waste constituents in surface water, wetlands or on the soil surface;
- Prevention of any releases that may have adverse effects on human health or the environment due to migration of waste constituents in air; and
- References.

Patterns of land use in the area are described in Attachment 3-1, DTTF Facility Description. The volume and physical and chemical characteristics of waste treated at the unit are described in Attachment 3-2, DTTF Waste Analysis Plan. Potential damage to wildlife and vegetation are described in *DTTF Ecological Risk Assessment* (CH2M Hill, 2006).

2.0 PREVENTION OF ANY RELEASES THAT MAY HAVE ADVERSE EFFECTS ON HUMAN HEALTH OR THE ENVIRONMENT DUE TO MIGRATION OF WASTE CONSTITUENTS IN THE GROUND WATER OR SUBSURFACE ENVIRONMENT: 40 CFR 264.601(a); R315-8-16, R315-3-2.14

This section describes:

- Potential for migration through soil, liners or other containing structures;
- Hydrologic and geologic characteristics of the unit and the surrounding area;
- Existing quality of ground water, including other sources of contamination and their cumulative impact on ground water;
- Quantity and direction of ground-water flow;
- Proximity to and withdrawal rates of current and potential ground water users;
- Potential for deposition or migration of waste constituents into subsurface physical structures, and into the root zone of food-chain crops and other vegetation;
- Potential for damage to domestic animals, crops and physical structures; and
- Additional information required.

2.1 Potential for migration through soil, liners or other containing structures

The potential for contaminant migration from the DTTF area to the first water-bearing interval is dependant upon the chemical nature of the contaminants relative to solubility and sorption, the porosity of the soil, and a transport mechanism. Waste composition is discussed in Attachment 3-2, DTTF Waste Analysis Plan. The majority of potential contaminants detected or expected within the DTTF area surface soils exhibit low solubilities and high partitioning coefficients or cation exchange capacities that greatly reduce the potential for contaminant mobility. Regardless of contaminant sorptive capacity and solubility, both a transport mechanism and porous media must be present to allow movement of contaminants from ground surface to the uppermost water-bearing unit. In the DTTF area, average rainfall is 8 inches per year, with effectively no infiltration of water to the uppermost aquifer. This is supported by visual evidence of ponding at ground surface (water then being removed via runoff and evaporation), and the presence of non-saturated strata below the 25-foot thick clay layer at ground surface in the DTTF area. (See Section 2.2 below for a detailed discussion of the hydrologic and geologic characteristics of the DTTF area.) Therefore, not only do potential contaminants generally exhibit low solubilities/high sorptive capacities, contaminant transport via surface water infiltration is highly unlikely in view of the site-specific geologic and climatic conditions. The operational and engineering controls in use at the open burn (OB) pans portion of the DTTF help ensure that the treatment operations have a minimal effect on the unsaturated zone. The open detonation (OD) treatment activities disturb the uppermost portion of the unsaturated zone due to explosions of PEP material. The disturbance of the material in the uppermost unsaturated zone due to explosions and the subsequent re-grading of the material using a road grader have a minimal effect on the overall character of the unsaturated zone material since the clay soil at the unit is homogeneous and is approximately 25 feet deep. It is highly unlikely that the open detonation (OD) treatment activities would have any effect upon groundwater flow under the DTTF.

Soil sampling supports the assumption that contamination from DTTF activities does not migrate through the soil to the unsaturated zone. In 1993, soil samples were collected at 17 locations in the OD portion of the DTTF. The locations were identified as B-1 through B-17. At each of the locations, soil samples were collected in sets from depths of 0.5 to 1 foot and 4.5 to 5 feet. One set of surface and subsurface soil samples (B-17) were collected from the approximate middle of the unit. Eight sets of surface and subsurface soil samples (B-1 through B-8) were collected approximately 100 feet from the center of the unit on all of the main compass points. Seven additional sets of soil samples were collected in a ring approximately 200 feet from the center of the unit. All of the samples were analyzed for the explosive residues and metals. In addition, five of the samples were analyzed for volatile and semivolatile organic compounds. The results of these analyses are summarized below and described in Kleinfelder 1993.

There were no explosive residues (DNT, HMX, RDX, or TNT) detected above the reporting limits or at trace levels below the reporting limits in any of the subsurface soil samples collected within the OD portion of the unit. There were also no volatile or semivolatile organic compounds detected above reporting limits in the five samples analyzed for these compounds. The presence of several tentatively identified compounds was noted in four of the semivolatile analyses. Total aliphatic hydrocarbons were tentatively identified at an estimated concentration of 2 mg/kg in one shallow soil sample and its duplicate. The aliphatic hydrocarbons C19 to C20 were identified at an estimated concentration of 0.4 mg/kg in one sample. The compound 2-(2-ethyloxyethoxy)-ethanol was identified in two samples at an estimated level of 0.3 and 0.4 mg/kg. The compound C16, unsaturated nitrile, was identified at a concentration of 0.1 mg/kg.

Soil samples collected from a depth of 0 to 5 feet were below background levels identified in the report *Final Characterization and Recommended Use of Facility-Wide Background Soil Metals Data* (Parsons 2001) with one exception. Two of the subsurface soil samples contained chromium (22 and 24 mg/kg) above the 20 mg/kg upper end of the background range. Soil samples collected at depths between the 5 foot and 97 foot interval had detections below the recommended reporting limit or below the background range. Details of the soil sampling and analysis are available in Kleinfelder 1993.

The use of burn pans reduces the presence of contaminants in the surface soil from open burning. The results of soil sampling and analysis support the premise that OD of PEP waste generates very little residue and that the OD activities conducted to date at the DTTF have had little adverse effect on the subsurface soils at the unit. In summary, OB and OD operations at the DTTF have a minimal potential to damage human health or the environment because of migration through soil or from the burn pans.

2.2 Hydrologic and Geologic Characteristics Of The Unit And Surrounding Area

Site-specific geologic data indicate that the DTTF is floored by the fluvo-lacustrine deposits of Lake Bonneville, and no eolian or "New Alluvium" sediments are present. Figure 1 presents a stratigraphic cross section through the DTTF, illustrating vertical and horizontal stratigraphic variations underlying the unit. Approximately 25 feet of light brown silty clay occurs immediately below the DTTF. Below this horizon, stratigraphy varies laterally within a 50 to 60 foot thick interval from thick sequences of gravel and clay (i.e., B-8) to more thinly interbedded sands, clays, and gravels (i.e., B-4). An approximately 20-foot clay-rich zone is present below this 50 to 60 foot gravel-bearing interval throughout the DTTF. First water was encountered beneath this clay interval approximately 95 feet below ground surface; drilling logs show that groundwater level rose above the zone within which the water was encountered, indicating that the first water is present under confined to semi-confined conditions.

Total thickness of the fluvo-lacustrine sediments below the DTTF is not known because boreholes were terminated at first water. However, data obtained from Wells No. 2, 3, 4 and 29 installed approximately 1 to 5 miles west of the unit imply that fluvo-lacustrine sediments can be approximately 100 feet thick in the DTTF. The nature of the geologic contact between fluvo-lacustrine and "Old Alluvium" was not specified in literature, but a gradational contact between the two units is implied. As shown in Figure 1, the clay-rich interval immediately below the unit grades vertically to interbedded clays, sands, and gravels below the DTTF to at least 100 feet below ground surface, and based upon regional data, likely grades into underlying "Old Alluvium," 100 to 200 feet below ground surface.

The uppermost water-bearing interval in the DTTF is nonpotable and occurs within a silty-sandy interval approximately 95 to 97 feet below ground surface, although "slightly moist" sediments were encountered in intervals above 90 feet. Potable water aquifers are confined, and available data indicate that the uppermost water-bearing interval below the DTTF may be confined or semi-confined because the static water level within each well is approximately eight feet above the water-bearing zone.

As shown in Figure 1, sediments between ground surface and the first water-bearing interval at the DTTF is comprised of gravels, sands, silts, and clays. Site-specific hydrologic data concerning these materials is not available, but Table 1 presents generalized horizontal hydraulic conductivities and porosities for these materials. The drilling logs for wells installed in the DTTF and discussions of the site-specific geologic materials are included in Kleinfelder 1993.

Table 1. Typical Hydraulic Conductivity and Porosity Values for Geologic Media

Media	Porosity Range (%)	Hydraulic Conductivity Range (m/s)
Gravel	25 - 40	10^{-3} to 1
Sand	25 - 50	10^{-6} to 10^{-2}
Silt	35 - 50	10^{-9} to 10^{-5}
Clay	40 - 70	10^{-12} to 10^{-9}
Sandstone	5 - 30	10^{-10} to 10^{-6}
Shale	0 - 10	10^{-13} to 10^{-9}
Fractured Crystalline Rock	0 - 10	10^{-8} to 10^{-4}

Source: Freeze and Cherry, 1979

2.3 Existing Quality of Ground Water, Including Other Sources of Contamination and Their Cumulative Impact on Ground Water

In 1993, four ground water monitoring wells were installed within the unit area at soil boring locations (B-2, B-4, B-6, B-8) as shown in Figure 2. The wells were drilled to the first (shallowest) water-bearing unit. The first encountered water-bearing unit is approximately 97 feet below ground surface. All wells were installed within the perimeter of the unit. An additional ground water sample was collected from within the auger at boring location B-17, although a monitoring well was not installed within this borehole. Detailed well construction information is included in Kleinfelder 1993. Each well was completed with 2-inch polyvinyl chloride (PVC), schedule 80, with the bottom 15 feet of each well casing constructed of 0.10-inch slotted well screen. The well annulus between the well screen and the inside of the boring was backfilled with #10-20 clean silica sand, with 5 feet of bentonite pellets emplaced above the silica sand. Bentonite grout was backfilled (tremied) atop the bentonite pellets to ground surface, and each well was capped with a 2-inch waterproof locking cap with a steel cover set in a concrete pad.

The four ground water monitoring wells (B-2, B-4, B-6, B-8) located at the DTTF were sampled and analyzed in 1993. A ground water grab sample was also collected from within the augers at Boring B-17. The sampling event information and detailed chemical analytical data are detailed in Kleinfelder 1993. Ground water quality data for samples collected during May and June of 1993 indicate that no explosive residues were detected in ground water above the quantitation limit. Filtered metal samples of barium, cadmium, chromium, and lead were detected at or above the quantitation limit in some of these samples. None of the metals were detected at concentrations above the Utah Maximum Contaminant Levels.

Ground water samples were collected from the four DTTF monitoring wells in July of 1997 (AGEISS 1997). The samples were analyzed for volatile organic constituents (SW-846 8360), semi-volatile organic compounds (SW-846 8270), explosives (SW-846 8330), total and dissolved metals (SW-846 6010), mercury (SW-846 7470), chloride (EPA 325.3), fluoride (EPA 340.2), sulfate (SW-846 9038), nitrate (EPA 353.2) and agent breakdown products (UT03, T8, UW22). Background water quality samples were collected from upgradient wells at nearby Consent Order Hazardous Waste Management Units 55, 58, and 90. These wells were selected as background wells based on boring logs, water level data, and potentiometric surface elevations. Data from these wells were used to determine statistical background values for the DTTF.

No organic analytes were detected in the ground water samples above the method detection limits.

The 1997 samples from the wells were analyzed for both dissolved and total inorganics including ICP metals, mercury, chloride, fluoride, nitrate and sulfate. Total iron and chromium were detected at concentrations greater than the statistical background values for the DTTF. Chromium was detected in one well at 29 micrograms per liter (ug/L), slightly above local background value for chromium of 28 ug/L. Iron was detected at concentrations ranging from 200 to 3500 ug/L. The statistical background value for iron is 178 ug/L, and is also above the secondary Maximum Contaminant Level of 300 ug/L. It is assumed that the detected levels of iron and chromium are not the result of groundwater contamination (see Section 2.7) but are localized background levels.

2.4 Quantity and Direction of Ground-water Flow

In the DTTF, site-specific groundwater flow data indicate that groundwater flow within the uppermost water-bearing interval is to the northwest as shown in Figure 2. Hydraulic gradient in the DTTF is 0.004 feet per foot (ft/ft). Site-specific hydraulic conductivity data are not available, but assuming that the aquifer is a silty sand to clay-rich silt, the optimal hydraulic conductivity could be approximately 1×10^{-5} meters per second (3.28×10^{-5} feet per second). Given these estimates and assuming a porosity of 30 percent (Table 1), the lateral groundwater flow rate is approximately 0.04 feet per day. References (EBASCO, 1992) state that "the deeper, confined fresh groundwater zones recharge the shallower brackish zones," implying that an upward flow gradient of sufficient head occurs between lower and upper water-bearing intervals to allow recharge. Interconnection of water-bearing intervals is not indicated due to the distinct differences in water quality, and intervening stratigraphic units which act as impediments to vertical groundwater flow. Because the intervals between ground surface and the first water-bearing zone are unsaturated and the interval contains porous zones that would contain vertically infiltrated water, the vertical infiltration rate is likely very low at the DTTF.

2.5 Proximity to and Withdrawal Rates of Current and Potential Ground Water Users

Production Wells 3, 4, 5, and 29 are approximately 1 to 5 miles from the DTTF. These wells are the closest wells to the DTTF and are downgradient of the unit. The screened interval of this water-bearing zone is over 300 feet below ground surface. Water extracted from these wells contains 150 to 250 mg/L $CaCO_3$, but is potable. Shallower water-bearing zones are present above the drinking-water zones in the Wells 3, 4, 5, and 29 areas, but shallower water is not potable.

Table 2 presents annual groundwater withdrawal from active drinking water supply wells at DPG. Wells 4 and 29 are currently inactive wells.

Table 2. Annual Groundwater Withdrawal from Active Drinking Water Supply Wells at DPG.

Well Number	Annual Withdrawal Rate (million gallons per year)								
	1969	1976	1980	1989	1994	1995	1996	1997	1998
3	A	23	12	13.2	3.14	4.3	6.12	13	6.12
5	A	43	15	4.4	1.31	4.08	1.09	2.13	3.87
26	80.8	37.5	64.7	30.3	16.6	12.2	22.6	20.3	19.4
27	110	55.7	104	90	17	15.6	16.8	16.5	15.5
28	A	19	18	44.5	6.9	5.46	6.58	10.8	6.74

A Data are not available.
SOURCES: Dugway 1982; Dugway 1990

2.6 Potential for Deposition or Migration of Waste Constituents into Subsurface Physical Structures, and into the Root Zone of Food-Chain Crops and other Vegetation

The results of the surface soil sampling indicate that operations at the unit have a minimal potential to damage human health or the environment. In addition, the soil within the DTTF is maintained completely clear of vegetation. Therefore, the potential for migration of waste to the root zone of food chain crops and other vegetation and the potential for damage to wildlife is minimal. The area around the unit is not used for grazing domestic animals or growing crops. Besides the burn pans, there are no physical structures in the DTTF that could be affected by the activities performed in the area, or by waste material released to the environment as a result of DTTF activities.

2.7 Groundwater Monitoring

R315-8-6.1 requires groundwater monitoring at non-land disposal facilities as determined to be necessary and appropriate by the Executive Secretary. DPG will monitor groundwater at the DTTF in accordance with the most current version of the Carr Regional Groundwater Monitoring Plan.

3.0 PREVENTION OF ANY RELEASES THAT MAY HAVE ADVERSE EFFECTS ON HUMAN HEALTH OR THE ENVIRONMENT DUE TO MIGRATION OF WASTE CONSTITUENTS IN SURFACE WATER, OR WETLANDS OR ON THE SOIL SURFACE: 40 CFR 264.601(b); R315-8-16, R315-3-2.14

This section describes the:

- Effectiveness and reliability of containing, confining and collecting systems and structures in preventing migration;
- Hydrologic characteristics of the unit and the surrounding area including the topography of the land around the unit;
- Patterns of precipitation in the region;
- Quantity, quality and direction of ground-water flow;
- Proximity of the unit to surface waters;
- Current and potential uses of nearby surface waters and any water quality standards established for those surface waters;
- Existing quality of surface waters and surface soils, including other sources of contamination and their cumulative impact on surface waters and surface soils;

- Potential for damage to domestic animals, crops and physical structures caused by exposure to waste constituents; and
- Additional information required.

3.1 Effectiveness and Reliability of Containing, Confining and Collecting Systems and Structures in Preventing Migration

The DTTF is designed and operated to minimize the migration of wastes to the soil surface. OB operations are conducted within burn pans that act to contain initiating materials and residual ash. Treatment operations are not conducted during inclement weather. The burn pans are kept covered when not in use and are covered after residue is removed after treatment or when residue is too hot to remove and must stay in the pan until cooled. Residual ash within the pan is collected and containerized within 24 hours after treatment. Typically, less than 5 pounds of residue remain after treating 1000 pounds of PEP waste. The burn pans are supported by steel I-beams which raise the bottom of the pans at least 6 inches above the soil surface to prevent run-on to the pans. As a result of the minimal amounts of explosive residue generated, proper residue control, and the presence of covers when the pans are not in use, no significant environmental contamination of the soil surface as a result of the current open burn operations is expected.

OD operations are conducted directly on the soil surface without any form of engineered control devices to prohibit contact with the soil in the unit. Liners and other structures are not used at the OD unit because they would likely be destroyed during normal treatment operations. The treatment of reactive and explosive waste by OD results in minimal amounts of explosive residues. Following each OD treatment event, the detonation area is visually inspected for signs of untreated waste and scrap metal or other debris. Untreated or incompletely treated wastes and contaminated scrap metal are re-detonated. Scrap metal that is free of explosives, based on visual inspection, is collected and disposed of or recycled. Hazardous waste is taken to the CHWSF. As a result of these operational controls, little or no environmental contamination of surface soils is expected as a result of OD operations at the unit.

3.2 Hydrologic Characteristics of the Unit and the Surrounding Area Including the Topography of the Land Around the Unit

The general direction of surface water drainage at DPG is to the northwest, onto the Great Salt Lake Desert. There are no permanent streams within the DPG boundaries. Streams flowing through DPG are ephemeral and intermittent, with surface water flow resulting from storm activity within the installation as well as from intermittent streams that exist in the mountains adjacent to DPG. Run-off from the mountain streams and precipitation within the installation flow through well established drainage channels. The surface water then either infiltrates into the alluvium of the stream channels or runs onto the flat plain of the desert where it evaporates quickly.

Government Creek is the major drainage feature in the vicinity of the DTTF and is located approximately one mile southwest of the unit at its closest point. Government Creek is an intermittent stream originating in the mountains approximately 17 miles southeast of the DTTF and flowing northwest. The total Government Creek drainage area is 181 square miles, 69 square miles of which is inside DPG boundaries. The slope of Government Creek varies from 0.17 percent near the DTTF to 25 percent in the mountains. Flash floods have occurred in the Government Creek drainage on four recorded occasions (1944, 1952, 1973, and 1983) following high precipitation events. The main areas affected were roadways in the Ditto Technical Center, located approximately five miles northwest of the DTTF. The flow of Government Creek is restricted by a road culvert in the Ditto area and the restriction causes the minor flooding of the area to the south. Although the 100-year flood boundary has not been established at DPG, the maximum width of the 100-year floodplain established for any drainage way in nearby counties is 1000 feet. Therefore, since the DTTF is greater than 1,000 feet from Government Creek, it is not likely that the DTTF is located in the 100-year floodplain of Government Creek. The location of Government Creek is shown in Figure 3.

The topography of the DTTF and the surrounding vicinity is relatively flat with a gentle slope of 48 feet/mile (0.01 ft/ft) toward the northwest. The elevation of the DTTF ranges from 4,415 to 4,427 feet AMSL. As shown in Figure 3, there are several small ephemeral drainage channels which approach the unit from the southeast. The path of the channels is interrupted at the boundary of the unit. Within the boundaries of the DTTF, all traces of these drainage channels have been eliminated by regular grading of the unit. The channels reappear outside the northwestern boundary of the unit and then continue in a northwest direction. Prior to construction of the DTTF, these channels flowed through the area now occupied by the DTTF. The drainage channels are difficult to locate on the ground surface and serve as drainage for a relatively small area several miles to the east and southeast of the unit. The drainage channels do not have a direct interaction with groundwater because the depth to groundwater in the area is greater than 90 feet. Although the DTTF is in the path of a drainage channel, inundation of the unit is not likely because the channels drain a relatively small area. According to facility personnel, the DTTF has never been inundated with run-on or run-off, even during the storm events that created the flash floods on Government Creek.

3.3 Patterns of Precipitation in the Region

Precipitation data for DPG are presented in Table 3, Precipitation Data for DPG at Ditto from 1950 to 1998. Data include the monthly mean, high, and low precipitation averages; numbers of days during which greater than 0.025, 0.25, 1.27, and 2.54 cm (0.01, 0.1, 0.5, and 1 inch) of rain fell; and mean and high snowfall. The data shows that mean annual precipitation is approximately 8 inches with a low of approximately 3 inches and a high of approximately 15 inches. The wettest months are March, April, and May, followed by October. Snowfall occurs November through March; however, snow may persist at mountain elevations for much longer periods than on flatlands.

Table 3. Precipitation Data for DPG at Ditto from 1950 to 2001.

	Precipitation in inches											Snowfall in inches		
Month/ Season	**Mean**	**High**	**Year**	**Low**	**Year**	**1 Day Maximum**		**# Days ^{3} 0.01**	**# Days ^{3} 0.10**	**# Days ^{3} 0.50**	**# Days ^{3} 1.00**	**Mean**	**High**	**Year**
January	0.53	1.54	1980	0.00	1961	0.79	01/25/52	5	2	0	0	4.0	13.9	1993
February	0.62	1.63	1998	0.00	1967	0.84	02/25/58	5	2	0	0	2.9	11.8	1955
March	0.80	2.44	1986	0.00	1956	1.34	03/08/86	6	3	0	0	2.6	21.2	1952
April	0.78	2.14	1986	0.04	1992	0.95	04/15/69	6	2	0	0	0.9	7.8	1970
May	1.01	2.96	1982	0.00	1969	1.24	05/31/94	6	3	0	0	0.2	6.4	1965
June	0.57	2.64	1997	0.00	1958	0.95	06/15/97	3	2	0	0	0.0	0.1	1951
July	0.54	1.89	1983	0.00	1963	1.11	07/31/83	4	2	0	0	0.0	0.0	1951
August	0.57	1.89	1983	0.00	1956	1.46	08/06/88	4	2	0	0	0.0	0.0	1951
September	0.59	3.16	1982	0.00	1952	1.17	09/17/61	3	2	0	0	0.0	0.0	1951
October	0.71	2.00	1981	0.00	1952	1.02	10/09/61	4	2	0	0	0.1	1.7	1956
November	0.57	1.86	1973	0.00	1959	0.95	11/15/63	4	2	0	0	1.9	8.8	1985
December	0.58	2.33	1983	0.00	1976	1.01	12/31/59	5	2	0	0	3.8	15.6	1968

Month/ Season	Precipitation in inches											Snowfall in inches		
	Mean	High	Year	Low	Year	1 Day Maximum		# Days ^{3} 0.01	# Days ^{3} 0.10	# Days ^{3} 0.50	# Days ^{3} 1.00	Mean	High	Year
Annual	7.86	15.07	1982	3.35	1966	1.46	08/06/88	57	25	3	0	16.3	31.3	1952
Winter	1.74	3.97	1997	0.32	1975	1.01	12/31/59	16	6	0	0	10.6	26.3	1993
Spring	2.59	6.32	1986	0.73	1966	1.34	03/08/86	18	9	1	0	3.7	21.2	1952
Summer	1.67	4.71	1984	0.02	1966	1.46	08/06/88	11	5	1	0	0.0	0.1	1951
Fall	1.86	5.79	1982	0.27	1953	1.17	09/17/61	12	6	1	0	2.0	8.2	1963

\# number

≥ greater than or equal to

SOURCE: WRCC 2003

3.4 Quantity, Quality and Direction of Ground-Water Flow

Quality of ground water is described in Section 2.3, Existing Quality of Ground Water, Including Other Sources of Contamination and Their Cumulative Impact on Ground Water. Quantity and direction of ground-water flow is described in Section 2.4, Quantity and Direction of Ground-water Flow.

3.5 Proximity of the Unit to Surface Waters

Government Creek is the major drainage feature in the vicinity of the DTTF and is located approximately one mile southwest of the unit at its closest point.

3.6 Current and Potential Uses of Nearby Surface Waters and any Water Quality Standards Established for those Surface Waters

There is no known use of surface water by humans at DTTF. There are no permanent or seasonal surface waters at the DTTF. However, wildlife could potentially use water that collects after summer storms.

3.7 Existing Quality of Surface Waters and Surface Soils, Including Other Sources of Contamination and their Cumulative Impact on Surface Waters and Surface Soils

There are no permanent or seasonal surface waters at the DTTF. Therefore, DTTF activities do not impact surface waters. Therefore, regular surface water monitoring is not required. Data has been collected to determine the impact of DTTF activities on DTTF soils.

In 1993, surface soil samples were collected from around each of the three burn pans at depths of 0 to 1 feet for a total of 24 samples. These samples were numbered SS-1 through SS-24. The locations of the samples are shown on Figure 4. To collect the samples, a circular sampling area was established surrounding each burn pan. The sampling area was divided into an inner sampling ring (approximately 10 feet from the pan) and an outer ring (approximately 35 feet from the pan). Four samples were collected at the center of each side of the burn pan in both the inner and outer rings (Kleinfelder 1993).

<u>Burn Pan No. 1</u> - The results of the surface soil analysis at Burn Pan No. 1 indicated that only one explosive residue compound (DNT) was present and it was detected at very low levels. DNT was detected in two of the inner ring samples and one of the outer ring samples at levels below the

reporting limit. Only one sample contained DNT (0.31 mg/kg) above the reporting limit. There were no volatile or semivolatile detections in the one inner ring sample analyzed for these constituents. The concentrations of metals reported for all of the Burn Pan No. 1 samples were within the background ranges with the following exceptions. The sample collected approximately 30 feet north of the pan contained 24 mg/kg of lead, which is above the upper range of the background samples. The sample collected from approximately 10 feet south of the unit contained levels of barium (300 mg/kg); cadmium (7.4 mg/kg); chromium (22 mg/kg); lead (29 mg/kg); and silver (3.6 mg/kg), which are above the upper range of the local background samples.

<u>Burn Pan No. 2</u> - The results of the surface soil analysis at Burn Pan No. 2 indicated that low levels of DNT, RDX, and TNT were present in the soil around the pan. DNT was reported at low levels (1.4 to 7 mg/kg) in all of the inner ring samples. Trace levels of DNT were detected below the reporting limit at two of the outer ring samples. RDX was detected below the reporting level in one of the inner ring samples and one of the outer ring samples. TNT was detected at 1.3 mg/kg in one of the inner ring samples. The concentrations of metals reported for all of the Burn Pan No. 2 samples were within background ranges with the exception of lead. Lead was reported above the background range in both the inner (25 mg/kg) and outer (68 mg/kg) ring samples north of the pan. Lead was reported at relatively elevated levels in samples collected within the burn pan (740 mg/kg) and south (250 mg/kg) of the pan. The residue that was sampled in the burn pan has subsequently been removed.

<u>Burn Pan No. 3</u> - The results of the surface soil analysis at Burn Pan No. 3 indicated that no explosive residues exceeded the reporting limits. No trace levels of explosive were detected below the reporting limits. There were also no volatile or semivolatile detections in the one inner ring sample analyzed for these constituents. The concentrations of metals reported for all of the Burn Pan No. 3 samples were lower than or within the range of background values.

It is possible that the detections in the OB Area resulted from burning operations conducted directly on the ground surface prior to installation of the burn pans in 1987. This is supported by the lack of detections above background and the reporting limit at Burn Pan No. 3, which is in an area of the unit not used prior to 1987. Details of the surface soil sampling at the burn pans are available in Kleinfelder 1993.

<u>OD Area</u> - Surface and shallow soil samples were collected at 17 locations in the OD portion of the DTTF. The locations were identified as B-1 through B-17 and are shown in Figure 4. At each of the locations, soil samples were collected in sets from depths of 0.5 to 1 foot. All of the samples were analyzed for the explosive residues and metals. In addition, five of the samples were analyzed for volatile and semivolatile organic compounds. The results of these analyses are discussed below and described in Kleinfelder 1993.

There were no explosive residues (DNT, HMX, RDX, or TNT) detected above the reporting limits or at trace levels below the reporting limits in any of the surface soil samples collected within the OD portion of the unit. There were also no volatile or semivolatile organic compounds detected above reporting limits in the five samples analyzed for these compounds. The presence of several tentatively identified compounds was noted in four of the semivolatile analyses. Total aliphatic hydrocarbons were tentatively identified at an estimated concentration of 2 mg/kg in one shallow soil sample and its duplicate. The aliphatic hydrocarbons C19 to C20 were identified at an estimated concentration of 0.4 mg/kg in one sample. The compound 2-(2-ethyloxyethoxy)-ethanol was identified in two samples at an estimated level of 0.3 and 0.4 mg/kg. The compound C16, unsaturated nitrile, was identified at a concentration of 0.1 mg/kg.

The concentrations of metals reported for all of the surface soil samples collected within the OD portion of the unit were below or within background ranges identified in the Facility-Wide Background Soil Metals Report (Parsons 1999). Details of the soil sampling and analysis are available in Kleinfelder 1993.

The results of these soil samples support the premise that OD of PEP waste generates very little residue and that the OD activities conducted to date at the DTTF have had little adverse effect on the surface or shallow soils at the unit.

Identified Solid Waste Management Units (SWMUs) occur near the DTTF that may impact surface soil and surface water quality upgradient of the DTTF. The occurrence of SWMUs near the unit, as well as potential SWMUs upgradient, indicate that sources of surface water and soil contamination from units other than the DTTF could be present in the area. Further, target/bomb artillery ranges that are upgradient of the DTTF may potentially impact soil and surface water quality upgradient of the DTTF.

3.8 Potential for Damage to Domestic Animals, Crops and Physical Structures Caused by Exposure to Waste Constituents

The results of the surface soil sampling indicate that OD operations at the unit have a minimal potential to damage human health or the environment. Although OB operations at the unit have resulted in low levels of surface soil contamination, the concentrations of metals detected in the soils near the burn pans are well below the health-based limits for those constituents for which health-based levels are available. In addition, the soil within the DTTF is maintained completely clear of vegetation. Therefore, the potential for migration of waste to the root zone of food chain crops and other vegetation and the potential for damage to wildlife is minimal. The area around the unit is not used for grazing domestic animals or growing crops. There are no structures located within or near the DTTF that could be damaged by migration of waste from the unit.

3.9 Proposed Soil Monitoring

Metals have been detected above background concentrations in surface soils at the DTTF (see Section 3.7). Additional soil sampling is recommended to determine the nature and extent of surface. Soil samples will be collected on an annual basis until it can be shown by a risk assessment that DTTF operations pose no risk to human health or the environment. Soil samples will normally be collected between May and October, when the DTTF is most active. Ideally, sampling will occur soon after a thermal treatment event.

At the OB area, at least two composite samples will be collected around each burn pan that has had a burn event during the previous year. The first composite will consist of at least four samples collected from different areas within 10 feet of the burn pan. The second composite will consist of at least four samples collect from different areas between 10 and 35 feet from the burn pan. Sampling locations will be documented using Global Positioning Satellite (GPS) or other appropriate method. Samples will be collected at a depth of 0-6 inches using a contaminant-free spade or scoop. The initial round of compliance sampling will include metals, explosives, and SVOCs/PAHs/dioxins. The results from this sampling event will be used to establish baseline or current conditions. For future compliance sampling, analytes of concern will be determined based upon the results of the initial sampling and the types of munitions treated at the DTTF. It is anticipated that compliance monitoring will only require analysis for metals and explosives. Approved methods, analytes, preservation, holding time, and container requirements are listed in Table 4.

At the OD area, at least five surface samples will be collected. To the extent possible, sampling locations should be chosen that are near the locations of detonations conducted during the previous year. Sampling locations will be documented using GPS or other appropriate method. Surface samples will be collected at a depth of 0-6 inches using a contaminant-free spade or scoop. The initial round of compliance sampling will include metals, explosives, and SVOCs/PAHs/dioxins. The results from this sampling event will be used to establish baseline or current conditions. For future compliance sampling, analytes of concern will be determined based upon the results of the initial sampling and the types of munitions treated at the DTTF. It is anticipated that compliance monitoring will only require analysis for metals and explosives. If munitions containing white phosphorus or perchlorates are treated, sample analyses will also address these constituents. If munitions containing white phosphorus or perchlorates are treated via OD, sample analyses will also address these constituents. Samples will be analyzed at a Utah-certified laboratory. Perchlorate samples will be analyzed by a State-approved laboratory. Approved methods, analytes, preservation, holding times, and container requirements are listed in Table 4.

Table 4. Soil Sampling Analysis Requirements

Parameter	Laboratory Method(s)*	Preservation	Holding Time	Container Requirements
RCRA Metals (Total As, Ba, Cd, Cr, Pb, Se, Ag)	6010/6020	Soil - None required	6 months	Glass or plastic
RCRA Metals (Total Hg)	7471	Soil - None required	28 days	Glass or plastic
SVOCs/PAHs	8270	Soil None; immediately chill to 4°C.-	14 days from sample collection to extraction; 40 days from extraction to analysis	Glass
Dioxins	8280	Soil – None; immediately place in dark and chill to 4°C.	45 days analysis holding time, 30 days extraction holding time	Glass
Explosives	8330	Soil – None required	14 days from sample collection to extraction and 40 days from extraction to analysis	Glass with Teflon-lined cap
White Phosphorus	7580 (Solvent extraction and GC)	Soil – None; immediately place in dark and chill to 4°C.	None specified, recommend 6 months	Glass
Perchlorate	6850 or 6860	Soil -	28 days	Amber glass

*Unless otherwise noted, methods are EPA SW-846 Methods. Use currently approved method revision

4.0 PREVENTION OF ANY RELEASES THAT MAY HAVE ADVERSE EFFECTS ON HUMAN HEALTH OR THE ENVIRONMENT DUE TO MIGRATION OF WASTE CONSTITUENTS IN AIR: 40 CFR 264.601(c); R315-8-16, R315-3-2.14

This section describes the:

- Potential for the emission and dispersal of gasses, aerosols and particulates,
- Effectiveness and reliability of systems and structures to reduce or prevent emissions of hazardous constituents to the air,
- Operating characteristics of the unit,
- Atmospheric, metrological, and topographic characteristics of the unit and the surrounding area,
- Existing quality of the air, including other sources of contamination and their cumulative impact on the air,

- Potential for health risks caused by human exposure to waste constituents, and
- Potential for damage to domestic animals, crops, and physical structures caused by exposure to waste constituents.

4.1 Potential for the Emission and Dispersal of Gasses, Aerosols and Particulates

Both open burning and open detonation will release potentially hazardous constituents to the air. That possibility is evaluated extensively in the *DTTF Ecological Risk Analysis*. Based upon a thorough risk analysis, this permit application contains DPG's approach to performing thermal treatments in a manner that does not exceed permissible levels for the emission of hazardous constituents to the air.

4.2 Effectiveness and Reliability of Systems and Structures to Reduce or Prevent Emissions of Hazardous Constituents to the Air

Operations of the DTTF are permitted under DPG's Title V Operating Permit was issued in February 2001. All air emissions are documented in DPG's operating permit program. The following meteorological requirements are set to minimize the impact of air emissions. DTTF operations will only be allowed under the meteorological conditions described in Module V of the Permit. There are no structures in place to minimize air emissions.

4.3 Operating Characteristics of the Unit

Operating characteristics of the unit are described in Attachment 3-1, Facility Description.

4.4 Atmospheric, Metrological, and Topographic Characteristics of the Unit and the Surrounding Area

DPG is located in a semi-arid, continental, steppe region, or high desert known as the Great Basin Desert. This region is often referred to as a cold desert due to its mid-latitude location. Typically winters are cold, summers are hot and dry with a high evaporation rate, and most precipitation falls in the spring.

Other weather characteristics typical of the DPG area include occasional electrical storms and dust storms in summer, and temperature inversion conditions in winter. Temperature inversion conditions occur when cold Arctic air spills into the area, wind speed is low, and contrary to the normal pattern, air temperature increases with height above the ground surface. Surface airflow is reduced and any tendency toward reduced air quality is aggravated under these conditions.

Weather patterns at DPG are influenced by the terrain. Most of DPG is relatively flat because it consists of a former lakebed (the former Lake Bonneville of which the Great Salt Lake is a small remnant). Interspersed in the flat terrain are abrupt often pinnacle-like mountains. These mountains are cooler and receive more precipitation than the surrounding flatlands. In addition, they influence local weather patterns by channeling winds and promoting up and down-slope conditions in the mornings and evenings, respectively.

Temperature data for DPG are presented in Table 5, Temperature Data for DPG at Ditto from 1950 to 1998. Data include the monthly average of the daily maximum, minimum, and mean; monthly extremes; and extremes of monthly averages. Records are for the period September 21, 1950 to

April 30, 1998. Temperature units are °F.

The data show that monthly average temperatures range from 25.5 °C (77.9 °F) in July, which is the hottest month, to –2.8 °C (27 °F) in January, which is the coolest. Daily extremes for each month show a substantial range. For example, for July the daily extreme high is 42.8 °C (109 °F) and the extreme low is 2.8 °C (37 °F), a range of 40.0 °C (72 °F). Similarly, the daily extreme range for January is 50.6 °C (91 °F). The large temperature fluctuations recorded between day and night and seasonally are typical of the area's arid continental climate.

DPG is surrounded by mountain ranges and peaks to the northeast, southeast, southwest, and west. This topography creates the distinct diurnal flow patterns that are modified by regional weather patterns, such as cold frontal systems or low-high pressure gradients. At night, radiative cooling of the mountain surfaces cools the air adjacent to those surfaces, causing the air to become denser at higher elevations. This denser air drains down the slopes and then is channeled down the axis of the valleys.

The mountain to valley circulation reverses on days with clear skies and light winds. As the mountain slopes are heated by solar radiation, the air above the slopes becomes warmer than the air at the same level over the valley resulting in upslope flow along the adjacent valley axis. Upslope flow is evident in the wind roses for the summer and fall afternoon periods. At most locations, the typical afternoon flow is from the northwest to north. Unlike drainage winds, which are associated with stable thermal stratifications, upslope winds are associated with unstable thermal stratifications, which enhance the turbulent mixing of the slope winds with the winds aloft. Consequently, upslope flows are more variable than downslope winds.

Table 5. Temperature Data for DPG at Ditto from 1950 to 2001.

	Monthly/Seasonal Averages			Monthly/Seasonal Extremes				Monthly/Seasonal Extremes				Max Temp		Min Temp	
Month/ Season	Daily Max °F	Daily Min °F	Daily Mean °F	High °F	Date	Low °F	Date	Highest Mean °F	Year	Lowest Mean °F	Year	³ 90 °F # Days	£ 32 °F # Days	£ 32 °F # Days	£ 0 °F # Days
January	38.0	16.1	27.0	66	01/10/53	-25	01/18/84	39.9	1953	15.1	1984	0.0	9.4	28.6	3.4
February	45.3	22.8	34.0	71	02/28/72	-29	02/07/89	41.5	1958	18.3	1984	0.0	3.2	24.2	0.9
March	53.6	28.6	41.1	80	03/24/56	-6	03/03/52	47.6	1978	33.7	1952	0.0	0.4	21.9	0.0
April	62.9	35.5	49.2	88	04/23/77	11	04/06/97	56.4	1992	41.4	1975	0.0	0.0	10.9	0.0
May	73.5	44.4	58.9	99	05/31/97	21	05/01/72	64.9	1969	53.0	1953	1.2	0.0	1.8	0.0
June	84.9	53.3	69.1	107	06/23/54	31	06/02/54	75.1	1961	63.5	1975	11.3	0.0	0.1	0.0
July	94.4	61.4	77.9	109	07/19/89	37	07/01/68	81.0	1989	70.8	1993	25.4	0.0	0.0	0.0
August	91.9	59.6	75.7	108	08/11/72	33	08/26/92	79.5	1970	69.9	1968	21.7	0.0	0.0	0.0
September	81.1	48.4	64.7	102	09/12/90	22	09/26/70	69.5	1979	58.0	1970	6.3	0.0	1.2	0.0
October	66.9	36.1	51.5	91	10/09/96	9	10/30/71	58.6	1963	46.2	1984	0.0	0.1	10.6	0.0
November	50.5	26.0	38.2	78	11/12/73	-8	11/27/52	46.2	1965	31.1	1993	0.0	1.0	23.8	0.2
December	39.2	18.1	28.6	69	12/01/95	-27	12/23/90	35.5	1973	17.2	1990	0.0	7.4	28.6	1.7
Annual	65.2	37.5	51.3	109	07/19/89	-29	02/07/89	53.6	1981	47.9	1993	66.0	21.5	151.6	6.3
Winter	40.8	19.0	29.9	71	02/28/72	-29	02/07/89	36.3	1978	20.7	1984	0.0	20.0	81.4	6.1
Spring	63.4	36.1	49.8	99	05/31/97	-6	03/03/52	55.3	1992	44.0	1975	1.2	0.4	34.6	0.0
Summer	90.4	58.1	74.2	109	07/19/89	31	06/02/54	77.7	1961	68.9	1993	58.4	0.0	0.1	0.0
Fall	66.1	36.8	51.5	102	09/12/90	-8	11/27/52	55.7	1963	47.5	1971	6.3	1.1	35.6	0.2

≥ greater than or equal to # number Max maximum Temp temperature

$\leq$	less than or equal to	°F	degrees Fahrenheit	Min	minimum

SOURCE: WRCC 2003

In summary, local wind patterns are governed by differential heating and cooling of the higher elevations relative to the flatlands and by regional weather. These patterns usually include the onset of southeasterly or southerly downslope flow at night that persist into morning, which transitions into northwesterly through northerly flow with daytime heating. There are two periods of relative atmospheric stability in the early morning and early evening hours. These patterns are marked in summertime but weak or absent in winter, due to differences in the amount of heat in the form of solar radiation received seasonally, and the tendency of snow to reflect solar radiation away during winter.

Wind conditions at DPG are measured at DPG's Surface Atmospheric Measurement System (SAMS) Locations at DPG. Data collected from Ditto's SAMS are used to model atmospheric dispersion patterns for DTTF activity modeling. An atmospheric dispersion model was required for DTTF activities for the air permit. Permit conditions defined as a result of atmospheric dispersion modeling are listed in Section 4.1, Effectiveness and Reliability of Systems and Structures to Reduce or Prevent Emissions of Hazardous Constituents to the Air.

The occurrence of unusual or severe weather conditions at the DPG Ditto/MAAF weather station are listed in Table 6, Occurrence of Unusual Weather Conditions at DPG. Data are reported through 1998.

Table 6. Occurrence of Unusual Weather Conditions at DPG.

Meteorological Condition	Annual Frequency (mean number of days/hours or percent of time)	Months with Greatest Average Frequency (in descending order)	Number of Years Recorded	Comments
Fog (Visibility < 7 mi)	27 days per year or 7% of the time	December January February	33	Winter occurrence
Thunderstorms or Electrical Storms	19 days per year or 5% of the time	July August	33	Summer occurrence
Cloud Ceiling < 200 ft and/or Visibility < 0.5 mi	61 hours per year or 0.7% of the time	December January	20	Winter and morning occurrence
Cloud Ceiling < 1,000 ft and/or Visibility < 2 mi	166 hours per year or 1.9% of the time	December January	20	Winter and morning occurrence
Cloud Ceiling < 1,500 ft and/or Visibility < 3 mi	228 hours per year or 2.6% of the time	December January	20	Winter and morning occurrence
Cloud Ceiling < 3,000 ft and/or Visibility < 3 mi	359 hours per year or 4.1% of the time	December January	20	Winter and morning occurrence

<	less than	Ft	foot or feet
%	percent	mi	mile(s)

SOURCE: National Oceanic and Atmospheric Administration

Dispersion of material released into the atmosphere occurs as a consequence of large scale and small-scale atmospheric motions. Motions that are large with respect to the volume of the released material tend to move the material along the direction of the mean flow. Smaller (turbulent) motions tend to disperse this material. The large-scale motions are characterized in terms of a time-averaged wind speed and direction. Turbulent motions are caused by the wind encountering flow obstacles (trees, buildings, hills, etc.) and by heating of air near the earth's surface. The effects of turbulent motion on dispersion are usually evaluated in terms of atmospheric stability. Turbulent motions and dispersion are suppressed in a stable atmosphere at night and are enhanced in an unstable atmosphere during the day.

The most commonly used measure of turbulence is a letter scale which uses commonly measured variables such as time of day, wind speed, and cloud cover to describe stability. A day with calm winds and bright sunshine would have greatly enhanced turbulent dispersion due to warm air bubbling off heated surfaces. This most unstable condition is designated as "Category A" stability. Letters "B" and "C" denote progressively weaker thermal enhancement of turbulent motions due to increased wind speed and/or cloud cover. "Category D" represents an atmosphere where turbulent dispersion receives no thermal enhancement. "Categories E, F," and "G" occur at night where radiative cooling suppresses turbulent motions. "Category G" represents the greatest degree of turbulence suppression that occurs with calm winds and clear skies. Dispersion is weakest under "Category G" stability.

"Categories D" and "E" are prevalent at DPG during winter months (December, January, and February). Nocturnal temperature inversions produce a shallow layer of cold, still air just above the earth's surface, causing "Category G" stability and poor dispersion. During summer months (June, July, and August), unstable categories "B" and "C" are common during the day. Stability categories "F" or "G" may occur during the evening and early morning hours when wind speeds approach zero.

4.5 Existing Quality of the Air, Including Other Sources of Contamination and their Cumulative Impact on the Air

DPG is located in an Air Quality Control Region that is in attainment with all applicable ambient air quality standards. DPG is designated as a Class II area. The nearest mandatory Class I areas to DPG are Capital Reef National Park in Utah and Craters of the Moon National Park in Idaho. DPG is approximately 240 km (150 mi) from Capital Reef National Park and 375 km (225 mi) from Craters of the Moon National Park. Permitting, air emissions, and air emission sources describe the air quality conditions at DPG.

DPG is considered a "minor" source under the PSD permitting program because it does not have the potential to emit more than 250 tons per year of a criteria pollutant. DPG is considered a "major" source under the operating permit program because it has the potential to emit more than 100 tons per year of a criteria pollutant. As a major source under the operating permit program, DPG complies with the documentation requirements of this program and identifies all regulations that are applicable to its operations. DPG submitted an Operating Permit Application to UDAQ under Utah R307-415 in 1995. DPG's Title V Operating Permit was initially issued in February, 2001 (UDAQ, 2001). All air emissions are documented in DPG's operating permit program.

DPG's operating permit program requires DPG to estimate the potential to emit and to conduct an inventory of emissions annually in accordance with Utah Air Conservation R307-155. The inventory consists of identifying emission sources and estimating annual emissions for criteria pollutants and

HAPs. DPG has conducted air emissions inventories each year since 1994. The 1996, 1997, and 1998 annual air emissions inventories are used as the baseline air emissions at DPG. These publicly available documents are located at the offices of the UDAQ.

4.6 Potential for Health Risks Caused by Human Exposure to Waste Constituents

There is minimal potential for public exposure to hazardous waste at the DTTF due to the distance of the unit to off-site and the extensive security measures in place at DPG. The closest entrance to DPG, which is manned 24 hours per day, is located approximately 9 miles northeast of the unit. DPG also operates security patrols that ensure only authorized personnel are allowed in the vicinity of the DTTF. The DTTF is located approximately 10 miles southwest of the nearest off-site occupied building and 7.5 miles southwest of the nearest on-site residence.

Potential risks to on-site receptors are described in the *DTTP Ecological Risk Assessment*.

4.7 Potential for Damage to Domestic Animals, Crops, and Physical Structures Caused by Exposure to Waste Constituents

The results of the air dispersion modeling indicate that OD operations at the unit have a minimal potential to damage human health or the environment. The potential for dispersed contaminants to migrate to the root zone of food chain crops and other vegetation and the potential for damage to wildlife is minimal. The area around the unit is not used for grazing domestic animals or growing crops. There are no structures located within or near the DTTF that could be damaged by exposure to waste constituents from the unit.

5.0 REFERENCES

AGEISS 1997. Field Activity Report for Groundwater Sampling at the Open Burn/Open Detonation Area, October 1997, AGEISS Environmental, Inc., Denver, Colorado.

AGEISS 2000-2002. Annual Criteria and Hazardous Air Pollutant Emission Inventories, 2000-2002, AGEISS Environmental, Inc., Denver, Colorado.

Army 1985. Ground-water Monitoring Study No. 38-26-0457-85, AMC Open-Burning/Open-Detonation Facilities, February 1984–March 1985, U.S. Army Environmental Hygiene Agency, Aberdeen Proving Ground, Maryland.

Dugway 1982. Installation Environmental Assessment for U.S. Army Dugway Proving Ground, Utah, 1982, Pinkham et al.

Dugway 1990. Master Plan Report for U.S. Army Dugway Proving Ground, Utah 1990, Higginbotham et al.

EBASCO 1992. Well Installation Plan for Landfills/Surface Impoundments at Dugway Proving Ground, 1992, Ebasco Services, Inc.

Freeze 1979. Groundwater Freeze, Allen R. and John A. Cherry. New Jersey, Prentice-Hall, Inc., 1979.

Kleinfelder 1993. Soil and Groundwater Investigation Open Burn/Open Detonation Site, Dugway Proving Ground, August 1993, Kleinfelder, Inc., Salt Lake City, Utah.

Parsons 2001. Final Characterization and Recommended Use of Facility-Wide Background Soil Metals Data, June 2001, Parsons Engineering Science, Inc., Denver, Colorado.

WRCC 2003. Utah Period of Monthly Climate Summary (1950 to 2001), February 2003, Western Regional Climate Center (WRCC)

Figure 1. Local Stratigraphic Cross Section Through the DTTF

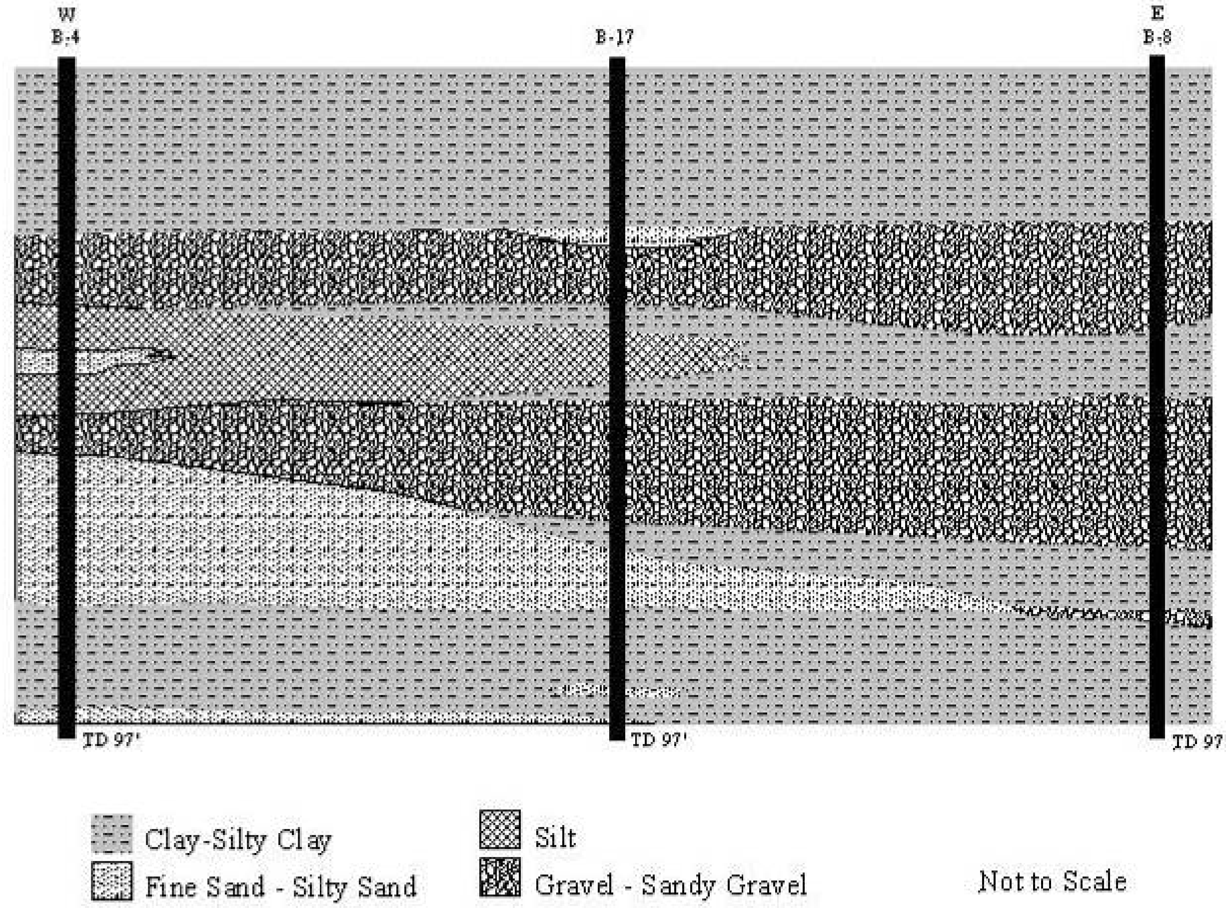


Figure 2. DTTF Water Table Map With Groundwater Monitoring Well Locations

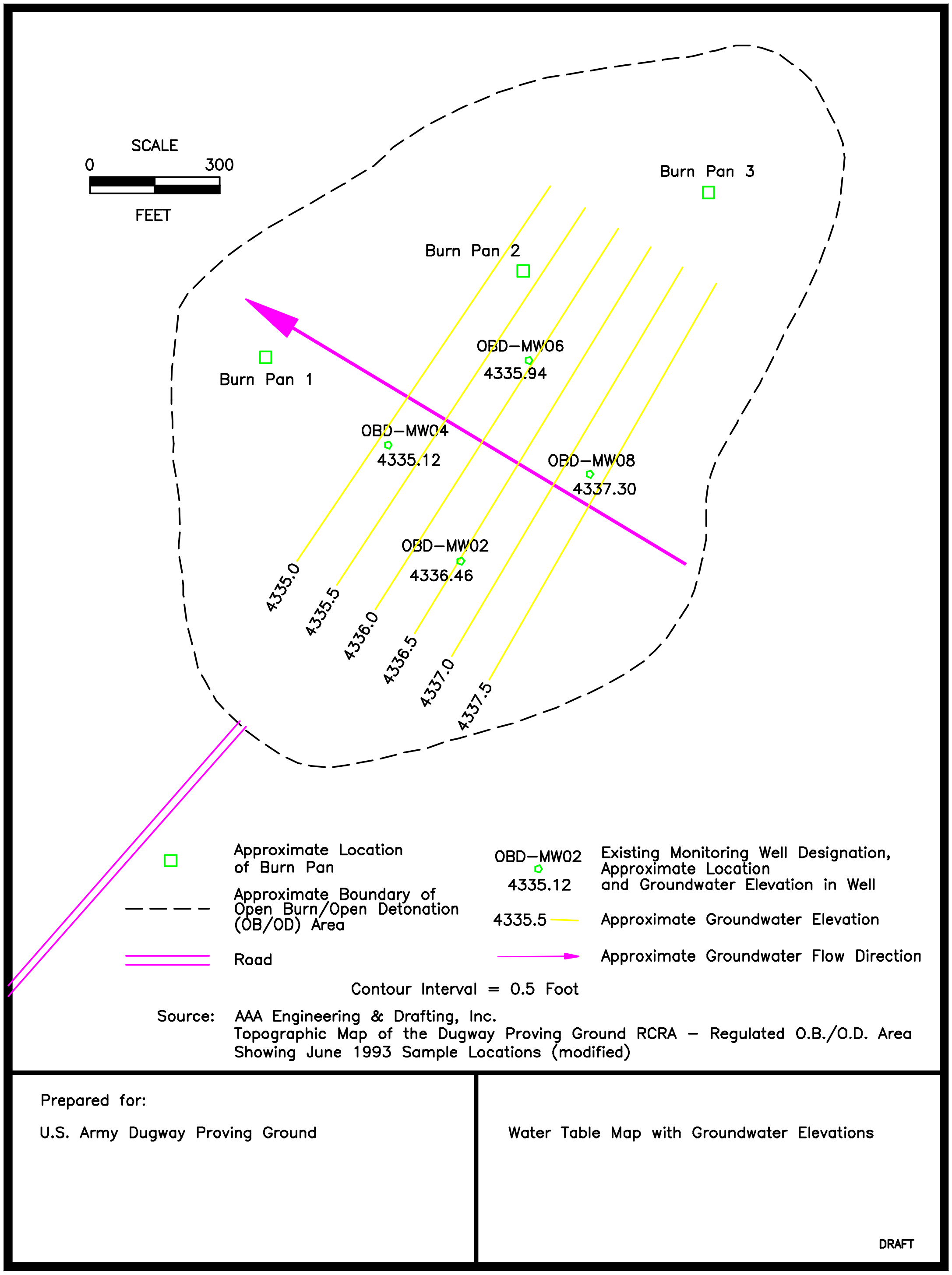
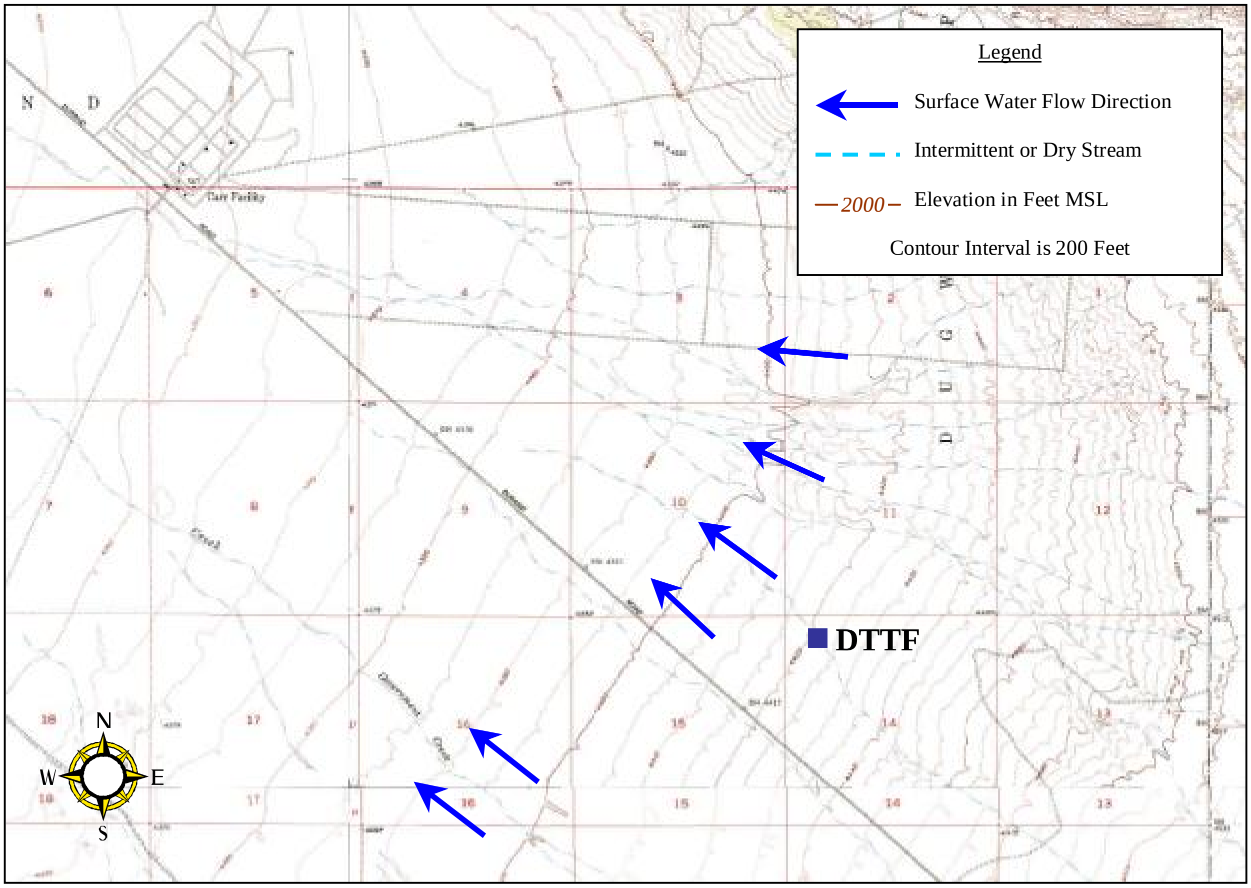


Figure 3. Surface Drainage and Topography Map for DPG



Source USGS Base Map, Tooele County, Utah

Figure 4. DTTF Soil Sampling Locations